Potentials of Parking and Floating Photovoltaics in Germany

Rachel Maier, Felix Kullmann, Jochen Linßen, Detlef Stolten

*ra.maier@fz-juelich.de

ENERDAY 2023

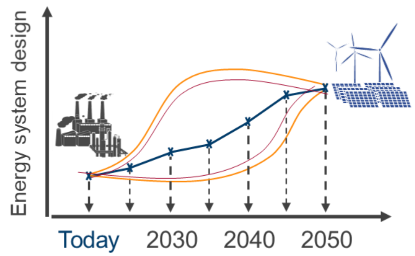
05.05.2023

IEK-3: Institute of Techno-economic Systems Analysis

Motivation and Definitions

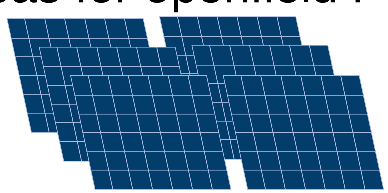
Climate Protection Act 2021 [1]

Goal of greenhouse gas neutrality in 2045



Studies analyse a high installed capacity for PV, among other renewable sources:
230 - 659 GW in 2045 [2-7]

Large required areas for openfield PV and land use conflicts



Draft of Photovoltaic Strategy 2023 [8]

One goal is to strengthen “special” PV categories, such as:

- Floating PV
- Parking PV
- Agri PV

Focus on floating and parking photovoltaics in Germany

Motivation and Definitions

Floating Photovoltaics

Definition: PV on water bodies

© BayWa r.e. [9]

Current Legislation

- Artificial & heavily modified waterbodies
- 40 m distance to shore
- Maximal 15% coverage

Existing Potential Analyses

- Germany: 44 GW technical potential on artificial lakes [11]
- Federal states studies for BW,BB,HH*

Parking Photovoltaics

Definition: Co-usage for parking & PV

© Iqony Solar Energy Solutions [10]

Current Legislation

- Only 5 federal states with legislation for new parking lots
- One criteria is the minimal parking spaces – ranges from 35, 50, and 100

Existing Potential Analyses

- Germany: 59 GW [11]
- Federal states studies for SH,BW,NI, HH,BB*

Potential analyses for floating and parking PV in line with current legislation

* BW: Baden-Württemberg, SH: Schleswig-Holstein, NI: Niedersachsen, HH: Hamburg, BB: Brandenburg

Methodology: Parking Photovoltaics (I / II)

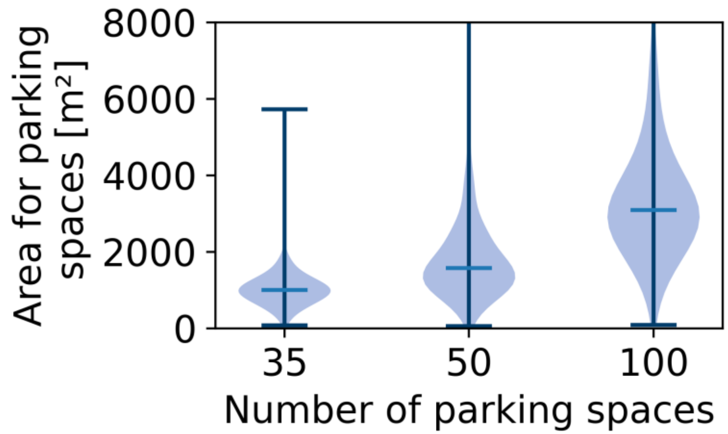
Scenario Definitions:

Existing parking lots with more than
a) 35 parking spaces
b) 50 parking spaces
c) 100 parking spaces

Only the parking spaces within the parking lots are assumed eligible for parking PV.

1. Relevant parking lots

Identification of relevant parking lots:
- No available data set with number of parking spaces for all parking lots in Germany
- Approximation with minimal area
  - Extraction of Open Street Map (OSM) [12] data with the information of number of parking spaces
  - Identifying the area for parking lots with the number of parking spaces



Area for parking spaces
- 35 : ~1000 m²
- 50: ~1600 m²
- 100 : ~3100 m²

Methodology: Parking Photovoltaics (II / II)

2. Exclusion of not eligible parking lots

Exclusion parking lots located in the following categories by WDPA [13]:

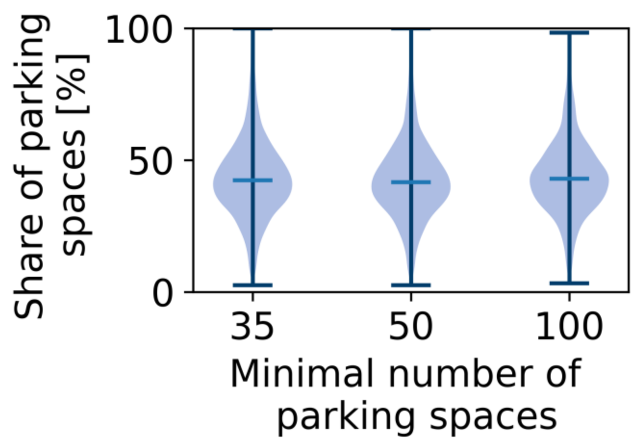
a) Birds Protection Area
b) National Parks
c) Nature Protection
d) Habitats

and the following by Basis-DLM [14]:
e) Forests

3. Area Coverage

Analysis of share of parking spaces within parking lots as area coverage:

- Assumed parking space size: 12.5 m²
- Extract parking lots from OSM [12] with parking space information and more than 35 parking spaces
- Calculate parking spaces area share



Parking Photovoltaics area coverage in parking lots: 42.2 %

Results:

Area Potential

Capacity density 200 MWp/km² [15]

Capacity Potential

Methodology: Floating Photovoltaics (I / II)

Scenario Definition in line with legislation

- Artificial or highly modified water bodies
- 40 m distance to shore
- Maximum share of 15% of the water body

1. Identification of water bodies

Official data set *„Wasserkörper-DE (Wasserrahmenrichtlinie 3. Zyklus 2022-2027)“* [16] of the Federal Institute of Hydrology

BfG Bundesanstalt für Gewässerkunde

Data set:
Filter: "`MODIFIED = 'Y' OR ARTIFICIAL = 'Y'`"

2. Exclusion of not eligible water bodies

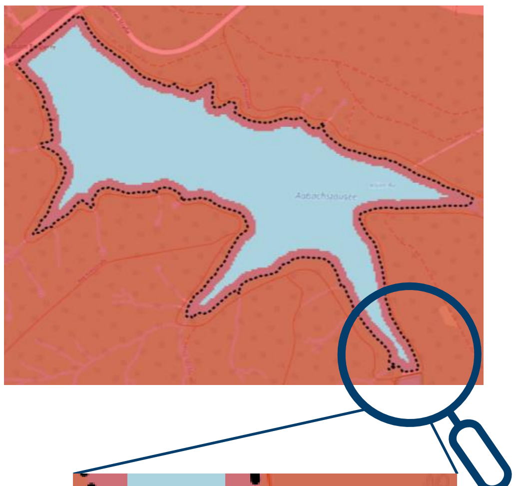
Exclusion of water bodies located in the following categories by WDPA [13]:

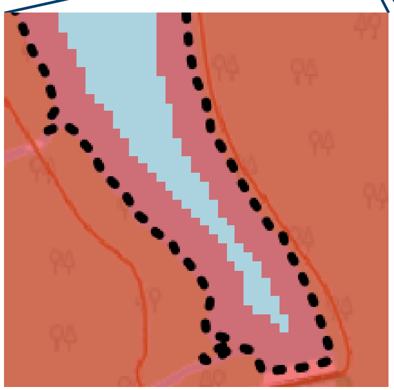
a) Birds Protection Area
b) National Parks
c) Nature Protection
d) Habitats

Methodology: Floating Photovoltaics (II / II)

3. Shore

Exclude area 40 m from shore





4. Maximal lake share

Legislation: Maximum coverage of 15% per water body

Approach per water body:

$$\frac{Area\ after\ Exclusions}{Total\ Water\ Body\ Area}$$

$< 15\%$ → $Area\ Potential = Area\ after\ Exclusions$

$\geq 15\%$ → $Area\ Potential = 0.15 * Total\ Water\ Body\ Area$

Results:

Area Potential

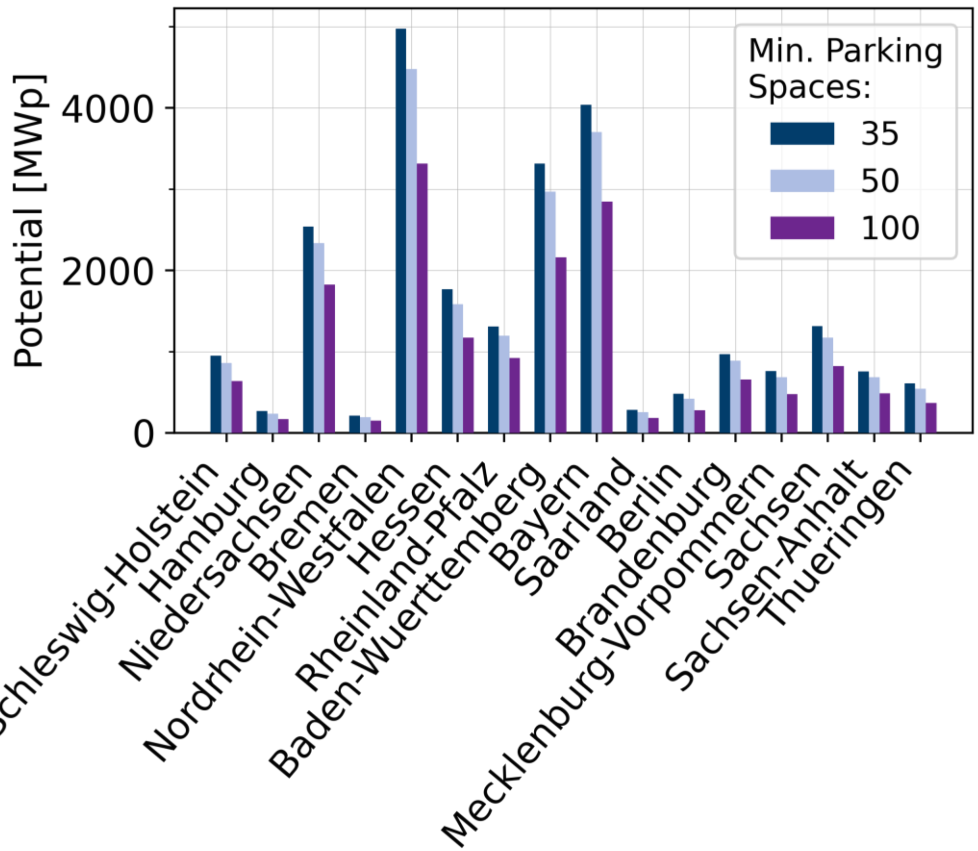
↓ Capacity density 100 MW/km²

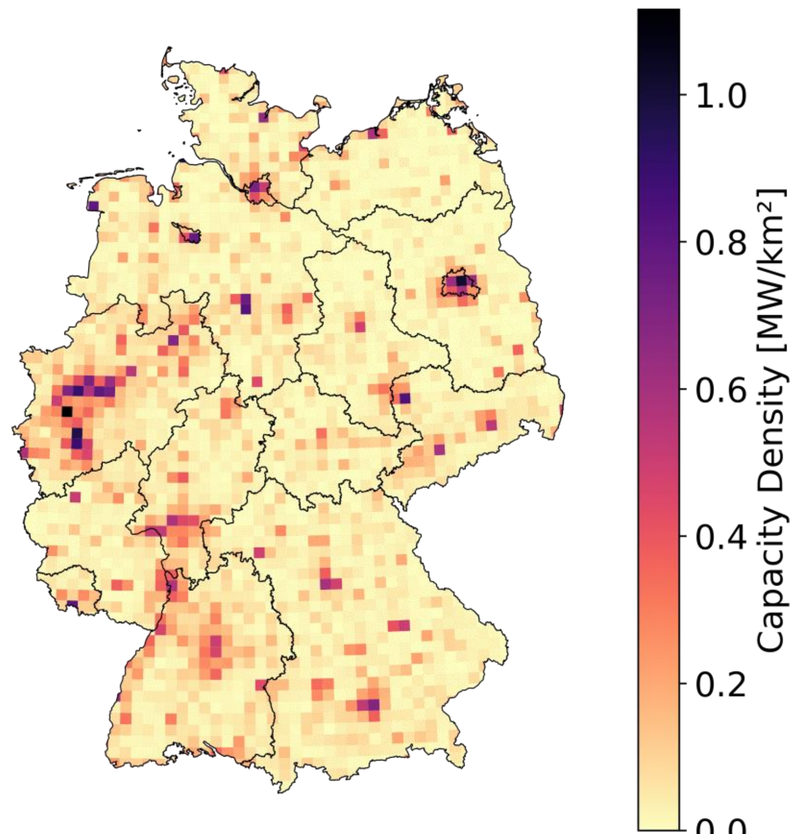
Capacity Potential

Results: Parking Photovoltaics

Parking PV potentials in Germany
on existing parking lots with more than …

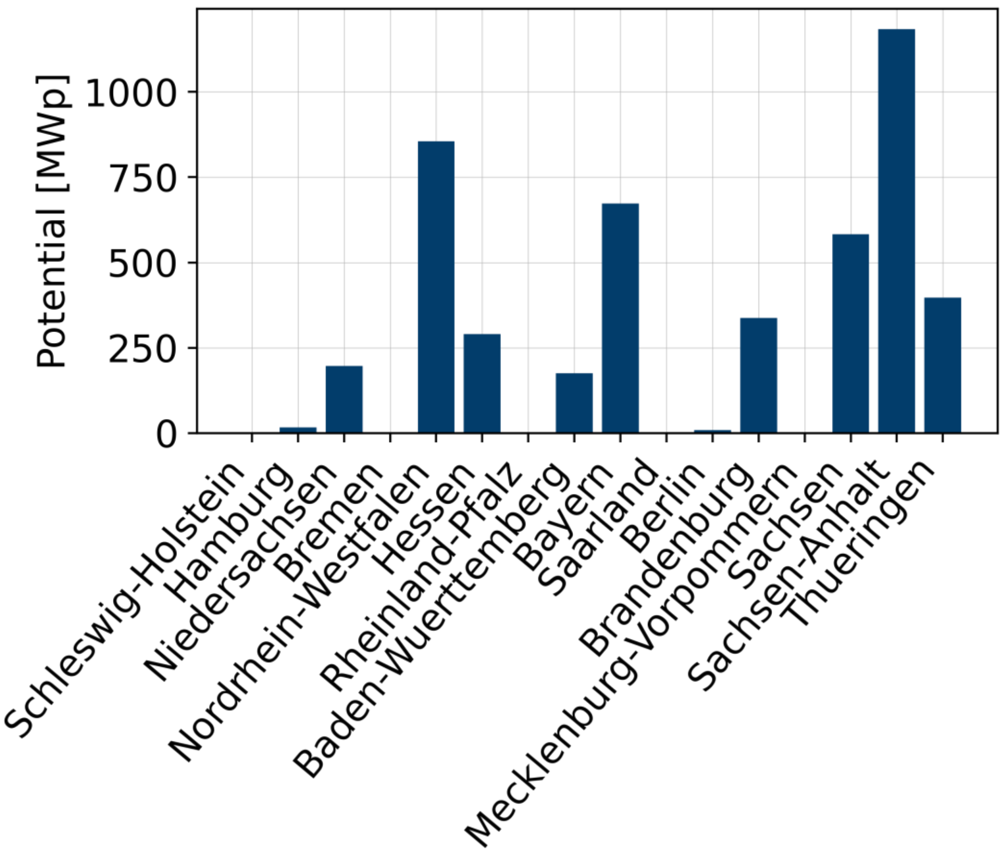
- 35 parking spaces: 24.6 GW
- 50 parking spaces: 22.2 GW
- 100 parking spaces: 16.5 GW

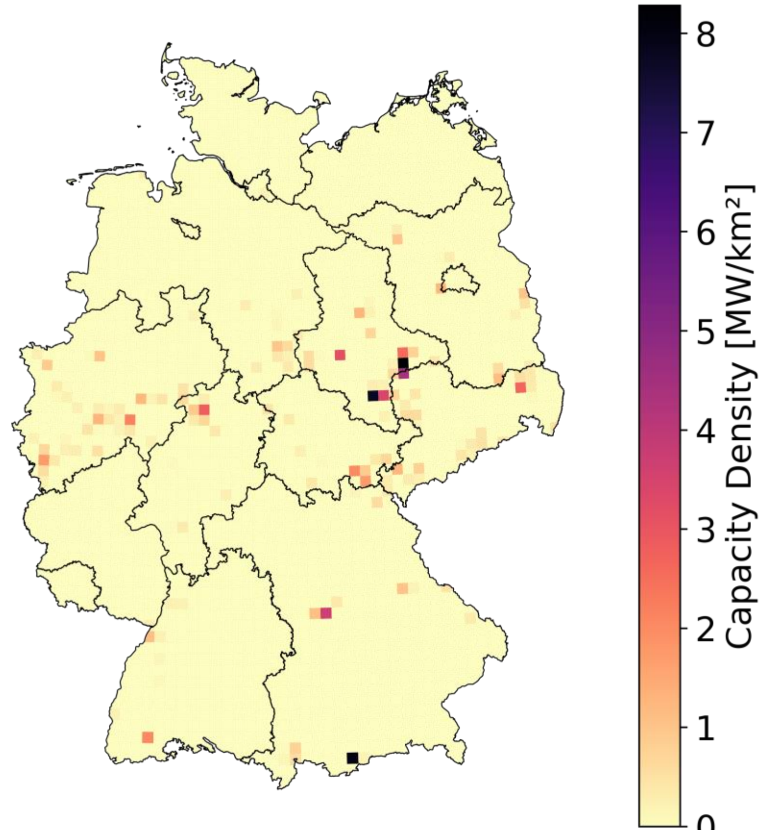




Results: Floating Photovoltaics

Floating PV Potential in Germany on artificial or heavily modified lakes: 4.7 GWp





Discussion

Relation to other PV potentials

Openfield PV:
- Poor Soil Quality: 124 GW [17]
- Side Stripes: 456 GW [17]

Agri PV: 1700 GW [11]

→ Comparably small potentials

Relation to PV targets for Germany

Study Results:
230 - 659 GW in 2045 [2-7]

→ Small possible contribution to the national targets for PV capacity

Impact of dual land use

Possible positive impacts, e.g. nexus of supply and demand in case of parking PV or reduced evaporation in case of floating PV.

Possible negative impact as biological changes, which require investigation.

Legislation

Floating PV:
- Current legislation modeled
- Increase potential by different lake definitions or higher area share

Parking PV:
- Only few federal states with legislation for newly built parking lots

Conclusion

Parking PV and Floating PV as option for dual land use with benefits and risks.

PV potential on existings parking lots between 16.5 and 24.6 GW.

Floating PV potential of 4.7 GW on artificial and highly modified lakes.

Both innovative PV categories with low possibilities to solve the upcoming land use conflicts for photovoltaic.

Literature

- [1] Bundes-Klimaschutzgesetz (KSG) (2021). https://www.gesetze-im-internet.de/ksg/KSG.pdf.
- [2] Boston Consulting Group. „Klimapfade 2.0“. Boston Consulting Group, Oktober 2021.
- [3] Stolten, Detlef, Peter Markewitz, Thomas Schöb, Felix Kullmann, Stanley Risch, Theresa Groß, Maximilian Hoffmann, u. a. „Neue Ziele auf alten Wegen? Strategien für eine treibhausgasneutrale Energieversorgung bis zum Jahr 2045“. Schriften des Forschungszentrums Jülich - Energie & Umwelt / Energy & Environment. Jülich: Forschungszentrum Jülich GmbH, 2022.
- [4] „Langfristszenarien für die Transformation des Energiesystems in Deutschland T45“, 22. November 2022. https://www.langfristszenarien.de/enertile-explorer-wAssets/docs/LFS3_T45_Webinar_Angebot_Nov_2022_final_webinarversion.pdf.
- [5] Deutsche Energie-Agentur GmbH (dena). „dena-Leitstudie Aufbruch Klimaneutralität“. Deutsche Energie-Agentur GmbH (dena), Oktober 2021.
- [6] Prognos, Öko-Institut, Wuppertal-Institut. „Klimaneutrales Deutschland 2045. Wie Deutschland seine Klimaziele schon vor 2050 erreichen kann Langfassung im Auftrag von Stiftung Klimaneutralität“. Agora Energiewende und Agora Verkehrswende, 2021.
- [7], Julian, Markus Haun, Daniel Wrede, Patrick Jürgens, Christoph Kost, und Hans-Martin Henning. „Wege zu einem klimaneutralen Energiesystem“. Freiburg: Fraunhofer-Institut für Solare Energiesysteme ISE, November 2021. https://www.ise.fraunhofer.de/content/dam/ise/de/documents/publications/studies/Fraunhofer-ISE-Studie-Wege-zu-einem-klimaneutralen-Energiesystem-Update-Klimaneutralitaet-2045.pdf.
- [8] Bundesministerium für Wirtschaft und Klimaschutz (BMWK). „Photovoltaik-Strategie“. Bundesministerium für Wirtschaft und Klimaschutz (BMWK), März 2023. https://www.bmwk.de/Redaktion/DE/Publikationen/Energie/photovoltaik-stategie-2023.pdf?__blob=publicationFile&v=6.
- [9] https://www.baywa-re.de/de/solar/systemanwendungen/floating-pv#vorteile-floating-pv
- [10] https://www.sens-energy.com/de/pv-carport/
- [11] Wirth, Harry. „Aktuelle Fakten zur Photovoltaik in Deutschland“. Freiburg: Fraunhofer-Institut für Solare Energiesysteme ISE, 1. März 2023. https://www.ise.fraunhofer.de/content/dam/ise/de/documents/publications/studies/aktuelle-fakten-zur-photovoltaik-in-deutschland.pdf
- [12] OpenStreetMap contributors. „Open Street Map via overpass turbo“, 2021. https://www.openstreetmap.org/ and https://overpass-turbo.eu/.
- [13] UNEP-WCMC, IUCN. „The world database on protected areas“, 2016. https://www.protectedplanet.net/ 23.
- [14] Geobasisdaten: © GeoBasis-DE / BKG (2021). „Digitales Basis-Landschaftsmodell (Ebenen) (Basis-DLM)“, 2021.
- [15] Stryi-Hipp, Gerhard, Christoph Kost, Christian Schill, Cristina Balmus, Alexander März, Dominik Peper, und Bin Xu-Sigurdsson. „Gutachten Photovoltaik- und Solarthermieausbau in Schleswig-Holstein“, 16. Februar 2022. https://www.schleswig-holstein.de/DE/fachinhalte/E/energiewende/Downloads/gutachtenPV_ST_Ausbau.pdf?__blob=publicationFile&v=1.
- [16] WasserBLIcK/BfG und Zuständige Behörden der Länder. „Wasserkörper-DE (Wasserrahmenrichtlinie 3. Zyklus 2022-2027)“, 2020. https://geoportal.bafg. de/inspire/download/AM/servicefeed.xml.
- [17] Risch, Stanley, Rachel Maier, Junsong Du, Noah Pflugradt, Peter Stenzel, Leander Kotzur, und Detlef Stolten. „Potentials of Renewable Energy Sources in Germany and the Influence of Land Use Datasets“. *Energies* 15, Nr. 15 (30. Juli 2022): 5536. https://doi.org/10.3390/en15155536.

Vielen Dank für Ihre Aufmerksamkeit!

Bei weiteren Fragen wenden Sie sich bitte an:

Rachel Maier
ra.maier@fz-juelich.de

Prof. Dr. Detlef Stolten
+49(0)2461 61 5147
d.stolten@fz-juelich.de

Institut für Energie- und Klimaforschung
Techno-ökonomische Systemanalyse (IEK-3)
Forschungszentrum Jülich
www.fz-juelich.de